

REMARKS

Claims 2, 4, 5, 7, 9, 11,12, 14 and 18 currently appear in this application. The Office Action of February 20, 2004, and the Advisory Action of June 1, 2004, have been carefully studied. These claims define novel and unobvious subject matter under Sections 102 and 103 of 35 U.S.C., and therefore should be allowed. Applicants respectfully request favorable reconsideration, entry of the present amendment, and formal allowance of the claims.

Claims 1-5, 7-12 and 14-18 are rejected under 35 U.S.C. 103(a) as being unpatentable over Kamiya et al. in view of Chen, Sr. et al. Kamiya et al. are said to teach a sliding bearing and method of making the sliding bearing wherein a resin surface layer is provided on a roughened surface of an aluminum bearing alloy layer on a metal backing, and then heated or fired to harden the surface layers. An intermediate bonding layer may be first applied to the roughened surface, this resin surface layer comprising a polyimide binder and a solid lubricant. A friction adjusting agent may be included.

The Examiner concedes that Kamiya et al. do not teach the resin is a polybenzimidazole. Chen, Sr. et al. are said to teach a miscible blend of polybenzimidazoles and polyamideimides which can be compounded with graphite or molybdenum disulfide to produce surfaces for bearings. The

Examiner's contention is that one skilled in the art would have been motivated to use polybenzimidazole in place of, or bonded with, polyimide resins. This rejection is respectfully traversed.

Claims 1, 3, 8, 10 and 15-17 have been cancelled, and claim 2 has been amended. Claim 2 provides a sliding bearing comprising a bearing alloy having a sliding surface, a bonding layer comprising a thermosetting resin further comprising one or more of polyamide-imide, epoxy resin and phenol resin which bonding layer is provided on the sliding surface of the bearing alloy layer, and a resin surface layer provided on the bonding layer. The resin surface layer contains 20-95% by volume of polybenzimidazole as a base resin and 5-80% by volume of a solid lubricant.

Claim 2 recites that the bonding layer comprises a thermosetting resin further comprising one or more of polyamide-imide, epoxy resin and phenol resin, which bonding layer is provided on the sliding surface of the bearing alloy layer. The bonding layer is specifically provided for improving bonding strength between the bearing alloy layer and the resin surface layer. It is respectfully submitted that this bonding layer is different from that of Kamiya et al. Kamiya et al. disclose that "when the sliding bearing materials have different colors, it is possible to investigate

and specify the place, depth, and number of the local-contact and the cause thereof and to feed back the obtained information to the design of the bearing and the shaft." Furthermore, in order to improve the bonding between the coating layer and the bearing alloy layer, Kamiya et al. disclose that the bearing alloy surface is required to be roughened for improvement in the bonding performance, and that a chemical conversion treatment is required for further improvement in the bonding performance (column 3, lines 16-29). Thus, in Kamiya et al., two coating layers have different colors in order that the place, depth and number of the local-contact may be investigated. However, Kamiya et al. fail to disclose that a bonding force of the lower layer, closer to the bearing alloy, is increased. Moreover, Kamiya et al. disclose other means for improving the bonding force, that is, roughening and chemical conversion treatment. Accordingly, Kamiya et al. neither disclose nor suggest anything about providing a bonding layer comprising a thermosetting resin so that a bonding force is improved between the bearing alloy layer and the resin surface layer. Consequently, Kamiya et al. do not teach the concept that two or more coating layers are used, and that a lower layer services as a bonding layer for improving the bonding strength.

Furthermore, Kamiya et al. do not teach that PI is used as a component of the bonding layer to improve bonding strength.

PAI is not a substance that is functionally equivalent to PI with respect to bonding properties. More specifically, PAI contains a water-absorptive amide group. Polyimide contains no amide group. Accordingly, the PI resin is hard and does not have sufficient elongation. ON the other hand, PAI is soft and has sufficient elongation for purpose of the present invention. It is clear from the differences in the properties of these two resins that a surprisingly greater bonding force is achieved n the claimed invention wherein PAI is used as a base resin of the bonding layer.

Chen, Sr. adds nothing Kamiya et al. to render the present invention obvious. The blends of polymers in Chen, Sr. et al. require the presence of a polyamide-imide having fluorine-containing linking groups. According to Chen, Sr. et al., it is the fluorine-containing linking groups that make it possible to provide blends of polybenzimidazoles and polyamide-imides. There is nothing in Chen, Sr. et al. that would lead one skilled in the art to consider using polybenzimidazole in place of, or blended with, a polyimide.

Claims 1-5, 7-12 and 14-18 are rejected under 35 U.S.C. 103(a) as being unpatentable over Kamiya et al. in view of Chen, Sr. et al. and further in view of Andres et al. or

White or Korshak et al. White is said to suggest that polybenzimidazole is a suitable material comparable to polyimides and polyamide imides when the bearing is subjected to high temperatures. Andres et al. are said to teach a self-lubricating composition comprising polybenzimidazole and internal lubricants such as graphite and boron nitride. Korshak et al. are said to teach that polybenzimidazole in conjunction with fillers such as MoS₂ provides excellent antifriction properties. This rejection is respectfully traversed.

White discloses at column 5, lines 28-35, that high temperature resins include epoxides, epoxy phenolic amide imides, polyimides, polybenzimidazole, polycarboranesiloxanes, and the like. However, as shown in Table 1 of page 3 of the present application, polybenzimidazole has higher heat resistance and material strength than the conventionally used thermosetting resins such as polyamide-imide, polyimide, and epoxy resins. Therefore, one skilled in the art reading White would not be motivated to use a resin other than polybenzimidazole. Andres et al. also add nothing to Kamiya et al. because Andres et al. merely disclose that polymeric composition containing internal lubricants is suitable for low friction applications. There is nothing in Andres et al. that would suggest using the polybenzimidazoles as a resin surface

layer of a bearing alloy. Despite the teaching of Korshak et al. that polybenzimidazole can be blended with molybdenum disulfide to produce an antifriction material, there is no indication that this composite is suitable for use on sliding bearings, or that such a mixture could be substituted for the resins disclosed in Kamiya et al.

Submitted herewith is a declaration of the inventors of the present application demonstrating that polybenzimidazole is not equivalent to PAI in bonding strength.

Additionally, the specification as filed demonstrates that polybenzimidazole (PBI) is not equivalent to PAI in bonding strength. The effects from the resin surface layer comprising PBI in the claimed invention are shown in the comparison between example 2 and comparative samples 15; comparison between example 3 and comparative sample 16; comparison between example 4 and comparative sample 17; comparison between example 5 and comparative sample 19; and comparison between example 6 and comparative sample 20. In each pair of example and comparative sample, all examples contain resin surface layers comprising PBI, whereas all of the comparative samples contain resin surface layer comprising PAI. The amount of PBI to be blended is the same as the amount of PAI to be blended.

Figure 3B of the application as filed shows that each example has the same or a lower coefficient of friction as compared to each comparative sample. Each example is superior to each comparative sample in the amount of wear, seizure load, and volumetric decrease. More specifically, regarding the amount of wear, example 2 exhibits a wear of 8 microns, whereas comparative sample 15 exhibits a wear of 17 microns. Example 3 has a wear of 16 microns, whereas comparative sample 16 has a wear of 20 microns. Regarding the seizure load, example 5 has 30 MPa, whereas comparative sample 19 has 24 MPa. Regarding volumetric decrease, example 3 has a decrease of 4.80 mm³, whereas comparative sample 16 has a decrease of 6.00 mm³. Thus, each example of the present application is superior to each comparative sample, the only difference being that the examples used PBI in the resin surface layers, while the comparative samples used PAI in the resin surface layers.

Furthermore, examples 2 and 7 were compared with each other. In both examples the resin surface layer comprised PBI. Example 2 had no bonding layer, while example 7 had a bonding layer. Examples 3 and 8 were also compared with each other in the same manner. Examples 6 and 9 were compared with each other in the same manner. Regarding friction coefficient and amount of wear, examples 7 to 9 have

similar values to those of examples 2, 3 and 6. Regarding seizure load and volumetric decrease, examples 7 to 9 are the equivalent of or superior to examples 2, 3 and 6.

Particularly with respect to volumetric decrease, examples 7 to 9 are superior to examples 2, 3, and 6, respectively.

It is clear from the foregoing that unexpected results can be achieved in the claimed invention with respect to the bonding strength of the bonding layer. Further more, the claimed invention is superior in wear amount, seizure load, and volumetric decreases. Therefore, it is clear that Kamiya et al. with any or all of the secondary references cannot achieve the herein claimed invention.

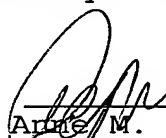
In view of the above, it is respectfully submitted that the claims are now in condition for allowance, and favorable action thereon is earnestly solicited.

Respectfully submitted,

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:) Art Unit: 1773
Takuya TANAKA et al.) Examiner: M. R. Jackson
Appln. No.: 10/076,417) Washington, D.C.
Date Filed: February 19, 2002) Confirmation No. 9295
For: SLIDING BEARING AND) ATTY.'S DOCKET: TANAKA=111
METHOD OF MANUFACTURING)
THE SAME)

DECLARATION UNDER 37 CFR 1.132

We, Takuya TANAKA, Nobutaka HIRAMATSU and Takayuki SHIBAYAMA, do hereby declare that we are the inventors of U.S. Serial No. 10/076,417.

Under our direction and control, experiments were conducted to compare the results obtained during a bonding test of samples. The samples used in the bonding test are examples 7 and 8 from the subject application, and comparative examples 15 to 20 as shown in Figures 3A and 3B of the instant specification and newly added references samples 1 and 2.

Referring to Figure A, a cylindrical member 2 having a diameter of 10 mm is bonded onto a surface of the resin surface layer side of sample 1 by an epoxy resin 3. Subsequently, a groove 4 was formed by a knife along an outer circumference of the cylindrical member 2 as shown in Figure B. The groove 4 has such a depth as to extend from the epoxy resin layer 3 via the resin surface layer 1a of sample 1 to the bearing alloy layer

1c. Figure B shows examples 7 and 8 and reference samples 1 and 2 in which each sample has a bonding layer 1b. In the case of comparative examples 15 to 20, no bonding layer 1b is made.

Sample 1 and cylindrical member 2 were hung on a tensile testing machine so that they could be pulled. The tensile force existing at the time sample 1 was broken served to demonstrate bonding strength. At the same time, the location where the breakage occurred was examined.

Results of bonding Strength Test

Figure C shows the composition of the resin layers of examples 7 and 8, and of comparative examples 15 to 20 and reference samples 1 and 2. Figure D shows the results of bonding strength test together with the results of other tests. Figures C and D show the composition of resin layers and other experimental results which have been shown in Figures 3A and 3B in the application as filed.

In each of comparative examples 15 to 20, a resin surface layer comprising PAI as a base is directly bonded to the bearing alloy layer (i.e., no bonding layer). Comparative examples 15 to 20 correspond to the invention of Kamiya et al.

It was noted that each of comparative examples 15 to 20 has a low bonding strength, and each of comparative examples 15 to 20 has been broken at a boundary between the bearing alloy layer and the resin surface layer. Consequently, the bearing alloy is exposed on the broken face of each of the comparative examples 15 to 20.

On the other hand, each of examples 7 and 8 has a high bonding strength. A maximum value is 5 MPa in the comparative examples

15 to 20, but in examples 7 and 8, the bonding strength is 16.4 and 10.5 MPa, respectively, which values are two or three times larger than the value of each comparative example. Furthermore, in examples 7 and 8, each broken face comprises a resin material, which supports the fact that the bonding layer has a high bonding strength.

Accordingly, when an abnormal force is applied to the bearing during operation, the resin surface layer is flaked such that the bearing alloy layer is exposed. As a result, the bearing alloy layer is sometimes rapidly seized. However, in examples 7 and 8 of the present application, the resin remains on the bearing alloy member, so that the bearing alloy layer is prevented from seizure.

Next, example 7 and reference sample 1 were compared with each other regarding bonding performance. Examples 8 and reference sample 2 were also compared with each other regarding bonding performance. Example 7 has the same composition of resin surface layer as reference sample 1, but differs from reference sample 1 in the composition of the bonding layer. Example 8 also has the same composition of resin surface layer as reference sample 2, but differs from reference sample 2 in the composition of the bonding layer. More specifically, the bonding layer of each of examples 7 and 8 contains 100% PAI, whereas the bonding layer of each of reference examples 1 and 2 contains 100% PI.

In conducting bonding strength tests as described above, it was found that reference samples 1 and 2 have a bonding strength of 13.9 MPa and 8.0 MPa respectively. Example 7 had the bonding strength of 16.4 MPa, and example 8 had the bonding strength of

10.5 MPa. These values are greater than those of reference examples 1 and 2. This shows that there is a clear difference between them when the resin surface layer comprising PBI as the base is bonded to the bearing alloy layer using PI as a bonding layer material or PAI as a bonding layer material. This difference results from the fact that PAI contains a water-absorptive amide group and has sufficient elongation, whereas PI contains no amide group and is hard and does not have sufficient elongation.

We hereby further declare that all statements made herein of our own knowledge are true and that all statements made on information and belief are believed to be true; and further that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 81 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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